[redacted]

Bellcomm

955 L'Enfant Plaza North, S.W.
Washington, D. C. 20024

date: July 26, 1971

to: Distribution

B71 07041

from: H. F. Connor

subject: Development of a Lunar Surface Model for the Apollo 15 Landing Site -- Case 310

ABSTRACT

This memorandum documents the development and preparation of a lunar surface model which was used for an LRV obstacle avoidance presentation to the Lunar Surface Operations Planning meeting at MSC on May 12, 1971. A crater model was generated to represent the expected distribution at crater diameters below the recognition level of the available site photography. A model for intercrater blocks was adopted from available literature. The resulting crater and block distributions were then applied statistically to a chart which became the basis for an examination of LRV obstacle avoidance traverse paths.

(NASA-CR-121359) DEVELOPMENT OF A LUNAR SURFACE MODEL FOR THE APOLLO 15 LANDING SITE (Bellcomm, Inc.) 8 p

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MEMORANDUM FOR FILE

Introduction

A lunar surface model was developed for an LRV obstacle avoidance study, presented to the Lunar Surface Operations Planning meeting at MSC on May 12, 1971 (Reference 1). A crater model was generated to represent the expected distribution at crater diameters below the recognition level of the existing site photography. A model for intercrater blocks was adopted from available literature. The resulting crater and block distributions were then applied statistically to a chart which became the basis for an examination of LRV obstacle avoidance traverse paths.

Crater Model

The accepted formula for cumulative crater distribution on the lunar surface is

$$N_c = AD^B$$

where N_c is the cumulative number of craters having diameters greater than D, per unit area. A and B are appropriate constants. Crater counts indicate that different sets of constants are required to represent the proper crater distributions for widely different diameter ranges. A single set of constants will generally suffice to represent diameters which span a range no greater than 100 to 1.

The crater distribution formula appears as a straight line on a log-log plot. A model can, therefore, be generated by locating one point and a slope which are representative of the desired region. A point for the Apollo 15 site was located by performing cumulative crater counts on several selected areas of Lunar Orbiter V Frame H-106. This high resolution frame covers an area north of the planned landing site, and shows craters at diameters well below the resolution of photography at the site. The cumulative crater counts averaged about 325 craters/sq. km for diameters in excess of 10 meters. The point representing these counts is shown in Figure 1.

The slope for the cumulative crater distribution on Figure 1 was obtained by making comparisons with counts performed by others on similar terrain types. Such counts require a very large quantity of photographic data and, for this study, needed to include as many counts as possible below the 32-meter diameter level. Data from crater counts of Lunar Orbiter high resolution frames (Reference 2) is shown on Figure 2. The data was selected from Reference 2 to represent only mare regions and to furnish a significant number of counts in the desired diameter range. Approximately 85,000 craters were involved in the generation of the three curves shown. A line was then drawn parallel to the upper limits of these curves and through the 10-meter cumulative point mentioned earlier to represent the Apollo 15 site estimate. This line is represented by

$$N_c = 0.024\ D^{-2.06}.$$

This estimate was also checked with data obtained from Ranger photographs (Reference 3) as shown in Figure 3. The Apollo 15 site estimate was converted to the incremental form to be consistent with the data available from Ranger and is seen to compare well with that data.

Block Model

An estimate for intercrater blocks on smooth mare was adopted from documentation prepared by Marshall Space Flight Center to support the design of lunar surface vehicles. This estimate is represented by

$$N_c = 1.57 \times 10^{-5}\ D^{-2.65}\ (*)$$

and is considered valid for block diameters less than 40 meters (Reference 4). Each block is expected to be buried to one-half its diameter. This cumulative block distribution is plotted on Figure 1.

(*)Converted to Km units from the original equation, which was expressed in meters as

$$N_c = 1.4 \times 10^{-4}\ D^{-2.65}.$$

Obstacle Sizes

An obstacle diameter of 32 meters was chosen as an upper limit for the study. This diameter is representative of the recognition threshold for existing photography of the Apollo 15 site.

Minimum obstacle diameters for craters and for blocks were selected separately after considering the following criteria which are pertinent to avoidance:

1. Visibility of the obstacle.

2. Availability of a clearer path.

3. Disturbance to the vehicle.

The expected crater distribution indicated that craters having diameters less than one-half meter would populate the terrain to such a degree that clear paths would not be present. The second criterion was, therefore, adopted as a minimum threshold for vehicle avoidance and craters in excess of one-half meter in diameter were considered for the study. It was not presumed that such craters would be visible at all times, nor that they would be excessively disturbing to the vehicle. For intercrater blocks, a minimum diameter of one-eighth meter was chosen as potentially disturbing to the vehicle. Clear paths are readily available among blocks of this size with the assumed distribution.

Charting

A chart was prepared for the obstacle avoidance study using the distribution formulae and obstacle size limits shown above. Craters and blocks were applied to an area which represented 20,000 square meters of lunar surface, using a set of random numbers to supply coordinate locations. A series of discrete sizes were chosen for the craters and blocks, each size representing the population density over a 2:1 diameter range.

Application

The chart was used as a physical model for a study of wander factor, maneuver requirements and speed of the LRV during driving traverses at the Apollo 15 site. The results of that study were reported in Reference 1.

HF Connor

2013-HFC-pjr H. F. Connor

Attachments

REFERENCES

1. Connor, H. F., Duty, D. M., and Richey, J. D., "LRV Lunar Traverse Obstacle Avoidance Study", Bellcomm Memorandum for File B71 06006, Cases 310 and 320, June 4, 1971.

2. Greeley, R., and Gault, D. E., "Precision Size-Frequency Distributions of Craters for 12 Selected Areas of the Lunar Surface", The Moon, Vol. 2, No. 1, September 1970.

3. Chapman, C. R., "Interpretation of the Diameter-Frequency Relation for Lunar Craters Photographed by Rangers VII, VIII, and IX", Icarus 8, 1-22 (1968).

4. "Natural Environmental Design Criteria for Use in the Design of Lunar Exploration Vehicles", Marshall Space Flight Center, Undated Document.

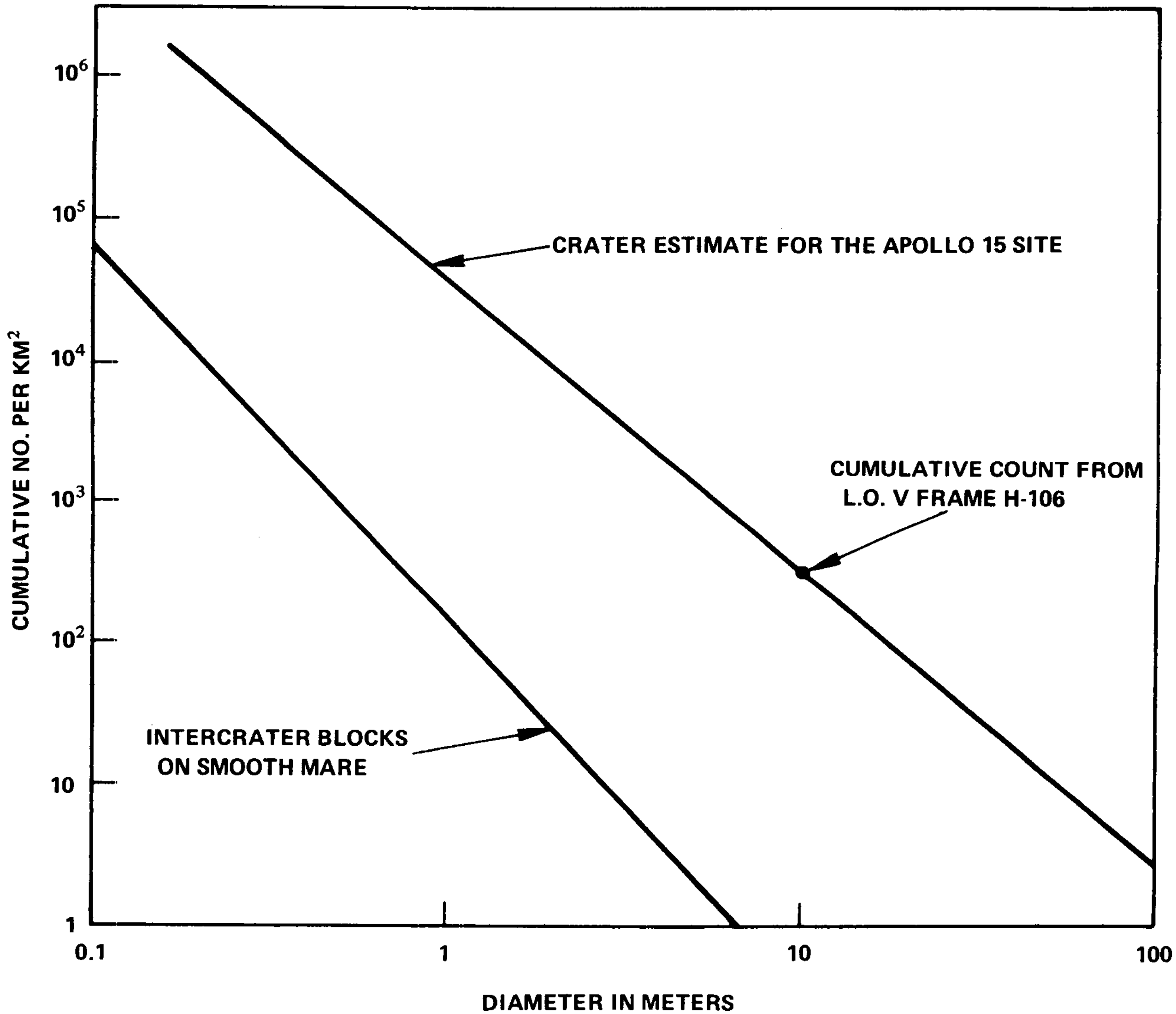

FIGURE 1 - CRATER AND INTERCRATER BLOCK DISTRIBUTIONS

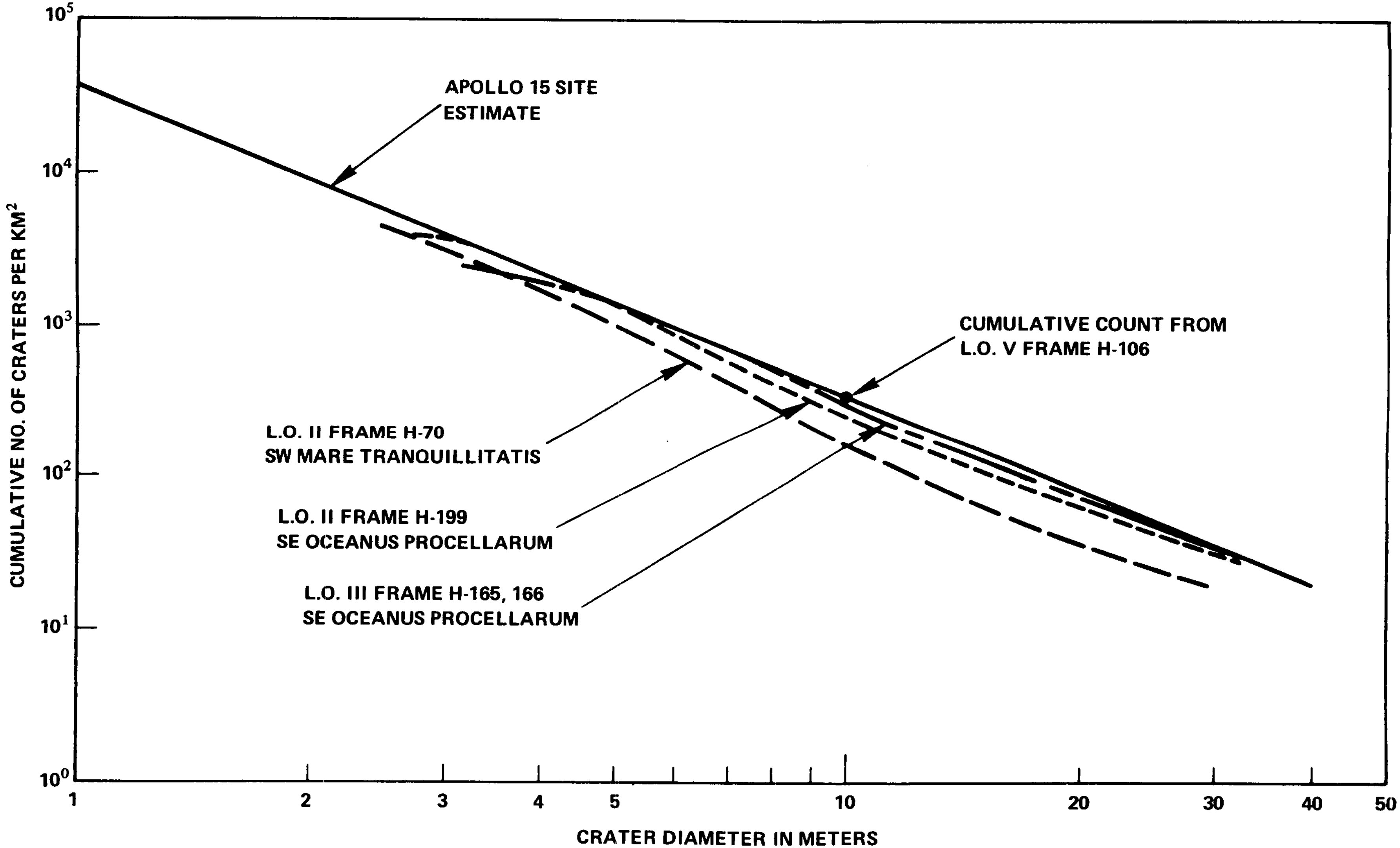

FIGURE 2 - SLOPE DETERMINATION FROM LUNAR ORBITER DATA

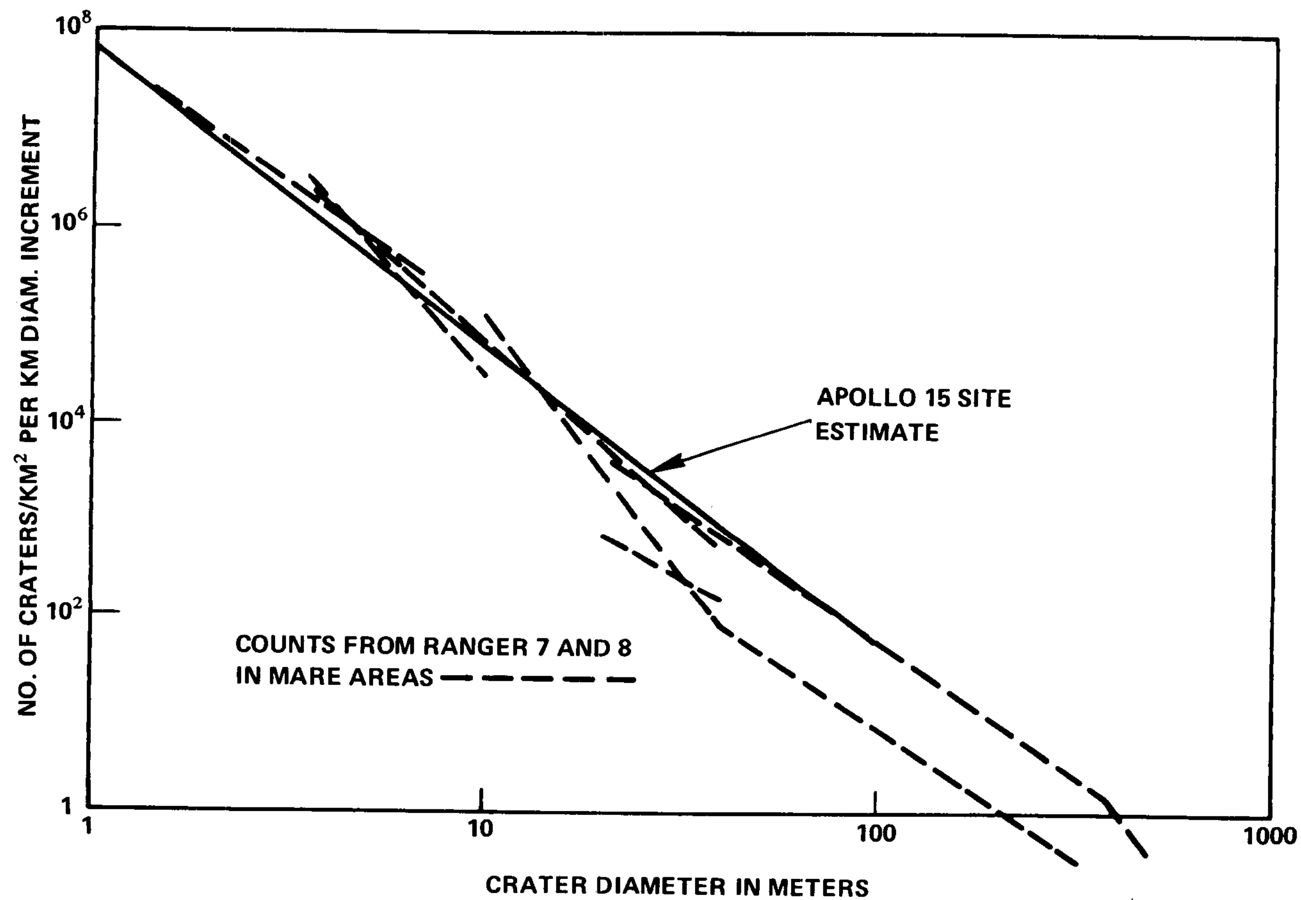

FIGURE 3 - COMPARISON OF APOLLO 15 SITE ESTIMATE WITH RANGER DATA (INCREMENTAL FORM)

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